

WHAT IS CLAIMED IS:

1. A detecting method for detecting internal resistance of an inspective rechargeable battery when said inspective rechargeable battery is charged by a constant current-constant voltage charging regime comprising a constant current charging mode and a constant voltage charging mode in that charging is commenced by said constant current charging mode at a constant current value I_0 and after the battery voltage of said inspective rechargeable battery reaches a given voltage value V_{max} , the charging is performed by said constant voltage charging mode at a constant voltage V_{max} until the termination thereof,

characterized in that said detecting method comprises at least a step (a) wherein an accumulated, charged electricity quantity of said inspective rechargeable battery in the constant voltage charging mode is obtained and a step (b) wherein said charged electricity quantity of said inspective rechargeable battery obtained in the constant voltage charging mode in said step (a) is referred to previously acquired data of a normal rechargeable battery, which corresponds to said inspective rechargeable battery, with respect to relationships of charged electricity quantities Q_{cv} thereof versus internal resistances thereof when

increased or decreased or their increased or decreased magnitudes in the constant voltage charging mode.

2. The detecting method according to claim 1, wherein said inspective rechargeable battery is a rechargeable
5 battery accommodated in a rechargeable battery pack having a control circuit in which one or more of a switching element for charging which is capable of performing ON-OFF control, a switching element for discharging, and a
10 detecting element for detecting a charging-and-discharging current value are accommodated in a charging-and-discharging path of said rechargeable battery.

3. The detecting method according to claim 1, wherein when said inspective rechargeable battery has an electricity storable capacity which is reduced to a
15 magnitude of D time that of said normal rechargeable battery [where D is a constant of $0 < D \leq 1$], said detecting method further includes a step (c) wherein said charged electricity quantity of said inspective
20 rechargeable battery in the constant voltage charging mode which is obtained in said step (a) is corrected by multiplying said charged electricity quantity by $1/D$ time and is referred to said previously acquired data of the normal rechargeable battery described in said step (b).

4. The detecting method according to claim 3, wherein
25 in a case where it is presumed that said electricity storable

capacity is reduced to a magnitude of D time that of said normal rechargeable battery, when a duration from shift time when the constant current charging mode at a constant current value I_0 is shifted to the constant voltage charging mode at a constant voltage V_{max} until a time when the charging current value in the constant voltage charging mode reaches a prescribed current value I_M and an electricity quantity charged in said constant voltage charging mode are made to be respectively t_M' and Q_{cv}' for the
5 inspective rechargeable battery and t_M and Q_{cv} for the normal rechargeable battery, in accordance with a function formula $D = (Q_{cv}' - I_0 \times t_M') / (Q_{cv} - I_0 \times t_M)$, the electricity storable capacity of the inspective rechargeable battery is estimated to be D time that of the normal rechargeable battery.

15 5. The detecting method according to claim 4, wherein said prescribed current value I_M is in a range of $0.4 \times I_0 \leq I_M \leq 0.6 \times I_0$ with respect to the charging current value I_0 in the constant current charging mode.

20 6. The detecting method according to claim 5, wherein said prescribed current value I_M is a half of said current value I_0 ; $I_M = 0.5 \times I_0$.

25 7. The detecting method according to claim 1, wherein said previously acquired data of said normal rechargeable battery with respect to relationships of charged electricity quantities Q_{cv} thereof versus

internal resistances thereof when increased or decreased or their increased or decreased magnitudes in the constant voltage charging mode include previously measured data of said relationships of said normal rechargeable battery, function formulas obtained from said measured data, and function formulas based on said measured data which are obtained by way of simulation by a computer.

8. The detecting method according to claim 7, wherein said previously acquired data of said normal rechargeable battery include data of relationships between charged electricity quantities Q_{cv} of said normal rechargeable battery and resistance values r_s based on resistors or data of relationships between said charged electricity quantities Q_{cv} and internal resistance values $(R_1 + r_s)$ of said normal rechargeable battery, which are obtained by a method wherein a plurality of resistors having a different resistance value (r_s) is separately connected to a normal rechargeable battery having an internal resistance value R_1 as said normal rechargeable battery in series connection to artificially increase said internal resistance value (R_1) of said normal rechargeable battery to a resistance value $(R_1 + r_s)$ as a pseudo-internal resistance value, and in each case, said normal rechargeable battery is charged by the constant current-constant voltage charging regime comprising a

constant current charging mode and a constant voltage charging mode in that charging is commenced by said constant current charging mode at a constant current value I_0 and after the battery voltage of said normal rechargeable battery reaches a given voltage value $V_{\max}$, the charging is performed by said constant voltage charging mode at a constant voltage $V_{\max}$ until the termination thereof, where a charged electricity quantity Q_{cv} of said normal rechargeable battery to which one of said plurality of resistors having a different resistance value (r_s) connected in series connection in the constant voltage charging mode is measured and relationship between said charged electricity quantity Q_{cv} and said artificially internal resistance value of said normal rechargeable battery is obtained in each case.

9. The detecting method according to claim 8, wherein the resistance value (r_s) of each resistor connected to said normal rechargeable battery is of substantially the same order as the internal resistance R_1 of said normal rechargeable battery or said resistance value (r_s) differs from said internal resistance R_1 by one digit.

10. The detecting method according to claim 8, wherein in each case where one of said plurality of resistors having a different resistance value (r_s) is connected to said normal rechargeable battery in series connection to

artificially increase said internal resistance value (R_1) of said normal rechargeable battery to a resistance value ($R_1 + r_s$), an open-circuit voltage V_{oc} of said normal rechargeable battery when the battery voltage reaches said voltage value V_{max} is measured and a charged electricity quantity Q_{cv} of said normal rechargeable battery in the constant voltage charging mode at that time is measured, and from said constant current value I_0 in the constant current charging mode, said measured open-circuit voltage V_{oc} and said measured charged electricity quantity Q_{cv} and from a function formula $R = (V_{max} - V_{oc})/I_0$, an internal resistance value of said normal rechargeable battery whose internal resistance value is artificially increased to ($R_1 + r_s$) is computed, and relationship between said measured charged electricity quantity Q_{cv} and said computed internal resistance value of said normal rechargeable battery is obtained in each case.

11. The detecting method according to claim 1, wherein a time point when said accumulated, charged electricity quantity of said inspective rechargeable in the constant voltage charging mode is measured is any of the following three time points:

(1) a time point when the charging current in the constant voltage charging mode is sufficiently decreased to a prescribed current value (I_{min}),

(2) a timepoint when a prescribed time (t_n) elapses since the time when the charging current value in the constant voltage charging mode reaches a prescribed current value (I_n), and

5 (3) a timepoint when a prescribed time (t_f) elapses since the time when the constant current charging mode is shifted to the constant voltage charging mode.

12. The detecting method according to claim 1, wherein after said internal resistance of said inspective
10 rechargeable battery is predicted to be R at a battery temperature T_0 on the basis of said previously acquired data of relationships of charged electricity quantities Q_{vc} versus internal resistances when increased or decreased or their increased or decreased magnitudes
15 with respect to said normal rechargeable battery which are described in said step (b), from an electricity storable capacity C_N of said normal rechargeable battery and a correction coefficient $f_{T,I}(R_1)$ for a discharged electricity quantity of said normal rechargeable battery which is decided by an
20 internal resistance R_1 of said normal rechargeable battery at a battery temperature T and a discharging current I , it is presumed that a total discharged electricity quantity C_d of said normal rechargeable battery whose internal resistance is R_1 is expressed by $C_d = C_N \times f_{T,I}(R_1)$ and a total
25 discharged electricity quantity C_d' of said inspective

rechargeable battery whose electricity storable capacity is not reduced is expressed by $C_d' = C_n \times f_{T,I}(R)$ [where $R (= R_1 + r_s)$ is an internal resistance of said inspective rechargeable battery], and when for an instrument in which said inspective rechargeable battery is used as a power source, an average consumption electric current thereof is made to be i and an average consumption power thereof is made to be p ; an average discharging voltage of said normal rechargeable battery when it is discharged at a discharging current value i is made to be V_m ; and an average discharging voltage of said inspective rechargeable battery when it is discharged at a discharging current value i is made to be V_m' , a time h during which said instrument is capable of being operated is computed in accordance with an equation $h = C_d' / i$ or $h = (V_m' \times C_d') / p$, where $V_m' = V_m - i \times (R - R_1) = V_m - i \times r_s$.

13. The detecting method according to claim 12, wherein said correction coefficient $f_{T,I}(R_1)$ for said discharged electricity quantity of said normal rechargeable battery and which is decided by an internal resistance R_1 of said normal rechargeable battery at a battery temperature T and a discharging current value I is selected from previously acquired data relating to correction coefficients for discharged electricity quantities and function formulas obtained by simulation by a computer based on said previously acquired data.

14. The detecting method according to claim 13,
wherein said previously acquired data of said normal
rechargeable battery include data of relationships
between internal resistance values $(R_1 + r_s)$ and
5 discharged electricity quantities C_d of said normal
rechargeable battery, which are obtained by a method
wherein a plurality of resistors having a different
resistance value (r_s) is separately connected to a
normal rechargeable battery having an internal resistance
10 value R_1 as said normal rechargeable battery in series
connection to artificially increase said internal
resistance value (R_1) of said normal rechargeable battery
to a resistance value $(R_1 + r_s)$ as a pseudo-internal
resistance value, and in each case, said normal
15 rechargeable battery is charged by the constant
current-constant voltage charging regime comprising a
constant current charging mode and a constant voltage
charging mode in that charging is commenced by said
constant current charging mode at a constant current value
20 I_0 and after the battery voltage of said normal
rechargeable battery reaches a given voltage value V_{max} ,
the charging is performed by said constant voltage
charging mode at a constant voltage V_{max} until the
termination thereof and after the charging is terminated, said
25 normal rechargeable battery is discharged at a prescribed

battery temperature T and a prescribed discharging current value I until the battery voltage of said normal rechargeable battery reaches a prescribed voltage value V_{min} , where a discharged electricity quantity C_d is measured, and
5 relationship between said measured discharged electricity quantity C_d and said artificially increased internal resistance value of said normal rechargeable battery is obtained in each case. [In a case where no resistor is connected to said normal rechargeable battery, namely, said
10 normal rechargeable battery is of the internal resistance R_1 and a discharged electricity quantity of said normal rechargeable battery is C_N at a battery temperature T_0 and a discharging current value I_0 , a correction coefficient $f_{T,I}(R_1)$ [where $T = T_0$ and $I = I_0$] for said discharged electricity
15 quantity of said normal rechargeable battery becomes to be C_d/C_N .]

15. The detecting method according to claim 14, wherein the resistance value (r_s) of each resistor connected to said normal rechargeable battery is of substantially
20 the same order as the internal resistance R_1 of said normal rechargeable battery or said resistance value (r_s) differs from said internal resistance R_1 by one digit.

16. The detecting method according to claim 13, wherein said previously acquired data of said normal
25 rechargeable battery include data of relationships

between internal resistance values ($R_1 + r_s$) and discharged electricity quantities C_d of said normal rechargeable battery, which are obtained by a method wherein a plurality of resistors having a different resistance value (r_s) is
5 separately connected to a normal rechargeable battery having an internal resistance value R_1 as said normal rechargeable battery in series connection to artificially increase said internal resistance value (R_1) of said normal rechargeable battery to a resistance
10 value ($R_1 + r_s$) as a pseudo-internal resistance value, and in each case, said normal rechargeable battery is charged by the constant current-constant voltage charging regime comprising a constant current charging mode and a constant voltage charging mode in that charging is
15 commenced by said constant current charging mode at a constant current value I_0 and after the battery voltage of said normal rechargeable battery reaches a given voltage value V_{max} , the charging is performed by said constant voltage charging mode at a constant voltage V_{max}
20 until the termination thereof and after the charging is terminated, said normal rechargeable battery is discharged at a prescribed battery temperature T and a prescribed discharging current value I until the battery voltage of said normal rechargeable battery reaches a prescribed voltage
25 value V_{min} , where a discharged electricity quantity C_d of

said normal rechargeable battery is measured, and an open-circuit voltage V_{oc} of said normal rechargeable battery when the battery voltage reaches said voltage value V_{max} in said constant current-constant voltage charging operation is measured, and from said constant current value I_0 in the constant current charging mode and said measured open-circuit voltage V_{oc} and in accordance with a function formula $R = (V_{max} - V_{oc}) / I_0$, an internal resistance value of said normal rechargeable battery whose internal resistance value is artificially increased to $R (= R_1 + r_s)$ is computed, and relationship between said measured discharged electricity quantity C_d and said computed internal resistance value R of said normal rechargeable battery is obtained in each case. [In a case where no resistor is connected to said normal rechargeable battery, namely, said normal rechargeable battery is of the internal resistance R_1 and a discharged electricity quantity of said normal rechargeable battery is C_N at a battery temperature T_0 and a discharging current value I_0 , a correction coefficient $f_{T,I}(R_1)$ [where $T = T_0$ and $I = I_0$] for said discharged electricity quantity of said normal rechargeable battery becomes to be C_d / C_N .]

17. The detecting method according to claim 16, wherein the resistance value (r_s) of each resistor connected to said normal rechargeable battery is of substantially the same order as the internal resistance R_1 of said normal

rechargeable battery or said resistance value (r_s) differs from said internal resistance R_1 by one digit.

18. The detecting method according to claim 12, wherein in a case where said inspective rechargeable battery whose internal resistance is predicted to be $R (= R_1 + r_s)$ has an electricity storable capacity which is reduced to a magnitude of D time [where D is a constant of $0 < D \leq 1$] that of said normal rechargeable battery, it is presumed that a total discharged electricity quantity C_d' of said inspective rechargeable battery is expressed by $C_d' = D \times C_N \times f_{T,I}(R)$ from said electricity storable capacity C_N of said normal rechargeable battery and a correction coefficient $f_{T,I}(R)$ for a discharged electricity quantity of said normal rechargeable battery whose internal resistance (R) is artificially increased by a magnitude of r_s , obtained at a battery temperature T and a discharging current I , and when for said instrument in which said inspective rechargeable battery is used as a power source, an average consumption electric current thereof is made to be i and an average consumption power thereof is made to be p ; an average discharging voltage of said normal rechargeable battery when it is discharged at a discharging current value i is made to be V_m ; and an average discharging voltage of said inspective rechargeable battery when it is discharged at a discharging current value i is made to be V_m' , a time h during

which said instrument is capable of being operated is computed in accordance with said equation $h = C_d' / i$ or $h = (V_m' \times C_d') / p$.

19. The detecting method according to claim 18,
5 wherein in a case where it is presumed that said electricity storable capacity of said inspective rechargeable battery is reduced to a magnitude of D time [where D is a constant of $0 < D \leq 1$] that of said normal rechargeable battery, when for said inspective rechargeable battery, a duration from sift
10 time when the constant current charging mode at a constant current value I_0 is shifted to the constant voltage charging mode at a constant voltage value V_{max} until the charging current value reaches a prescribed current value I_M is made to be t_M' and a charged electricity quantity in the
15 constant voltage charging mode is made to be Q_{cv}' and for said normal rechargeable battery, a duration from sift time when the constant current charging mode at a constant current value I_0 is shifted to the constant voltage charging mode at a constant voltage value V_{max} until the charging current value
20 reaches a prescribed current value I_M is made to be t_M and a charged electricity quantity in the constant voltage charging mode is made to be Q_{cv} , from a function formula $D = (Q_{cv}' - I_0 \times t_M') / (Q_{cv} - I_0 \times t_M)$, said said electricity storable capacity of said inspective rechargeable battery is
25 predicted to be D time that of said normal rechargeable

battery.

20. The detecting method according to claim 19, wherein said prescribed current value I_M is in a range of $0.4 \times I_0 \leq I_M \leq 0.6 \times I_0$.

5 21. The detecting method according to claim 19, wherein said prescribed current value I_M is $1/2$ of the charging current value I_0 in the constant current charging mode.

10 22. A detecting apparatus for detecting internal resistance of an inspective rechargeable battery when said inspective rechargeable battery is charged by a constant current-constant voltage charging regime comprising a constant current charging mode and a constant voltage charging mode in that charging is commenced by said constant current charging mode at a constant current value
15 I_0 and after the battery voltage reaches a given voltage value V_{max} , the charging is performed by said constant voltage charging mode at a constant voltage V_{max} until the termination thereof, said detecting apparatus having at least a means (i) for measuring a voltage of
20 said inspective rechargeable battery, a means (ii) for acquiring an accumulated, charged electricity quantity of said inspective rechargeable battery in the constant voltage charging mode, a means (iii) for memorizing previously acquired data of a normal rechargeable battery which
25 corresponds to said inspective rechargeable battery, with

respect to relationships of charged electricity quantities thereof in the constant voltage charging mode and internal resistances thereof when increased or decreased or their increased or decreased magnitudes, and a means (iv) for referring said charged electricity quantity of said inspective rechargeable battery in the constant voltage charging mode obtained by said means (ii) to information from said means (iii), wherein internal resistance of said inspective rechargeable battery is detected from information from said means (iv).

23. The detecting apparatus according to claim 22, wherein in a case where said inspective rechargeable battery has an electricity storable capacity which is reduced to a magnitude of D time [where D is a constant of $0 < D \leq 1$] that of said normal rechargeable battery, said detecting apparatus has a further means for correcting said charged electricity quantity of said inspective rechargeable battery in the constant voltage charging mode by multiplying said charged electricity quantity by $1/D$ time prior to referring to said information from said means (iii).

24. The detecting apparatus according to claim 22, wherein said inspective rechargeable battery is a rechargeable battery accommodated in a rechargeable battery pack.

25. The detecting apparatus according to claim 24, wherein said rechargeable battery pack has a rechargeable battery and a control circuit in which one or more of a switching element for charging which is capable of performing ON-OF control, a switching element for discharging, and a detecting element for detecting a charge-and-discharge current value are accommodated in a charging-and-discharging path of said rechargeable battery.

26. A rechargeable battery pack in which a detecting apparatus defined in claim 22 is accommodated.

27. An apparatus having a detecting apparatus defined in claim 22 added thereto.

28. The apparatus according to claim 27, wherein said apparatus from the group consisting of inspection equipments for inspecting a rechargeable battery whether said rechargeable battery is good or defective, chargers for charging a rechargeable battery, portable instruments including cellular phones, personal digital assistants, and portable type computers, and movable bodies including motorcycles, automobiles, ships, aircrafts, and space crafts).

29. A program for detecting internal resistance of an inspective rechargeable battery, said program having a detecting method defined in claim 1 incorporated therein.

30. A memory medium for detecting internal resistance of a rechargeable battery in which a program defined in claim

29 is stored.